

# Searching for white dwarfs candidates in Sloan Digital Sky Survey Data

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**Abstract.** Large amount of observational spectroscopic data are recently available from different observational projects, like Sloan Digital Sky Survey. It's become more urgent to identify white dwarfs stars based on data itself i.e. without modelling white dwarf atmospheres. In particular, existing methods of white dwarfs identification presented in Kleinman et al. (2004) and in Eisenstein et al. (2006) did not allow to find all the white dwarfs in examined data. We intend to test various criteria of searching for white dwarf candidates, based on photometric and spectral features.

## 1. Introduction

Because of their physical properties, white dwarfs stars are difficult to observe and identification. The first version of the McCook & Sion catalogue (1987) contains 1279 white dwarfs only. Recently, observational techniques was considerable improve, so the amount of photometric and spectral data rapidly grows. For this reason also the number of identified white dwarfs grows, but it is very needed to elaborate efficient identification and classification methods.

Until now, many of the white dwarf samples were selected, based on different selection criteria. For example Fleming et al. (1996) published a white dwarfs catalogue based on ROSAT data (Trumper 1983, 1992). A classification was made by searching for position coincidence between ROSAT sources and hot white dwarfs from McCook & Sion catalogue. Sources with no optical counterparts were marked as white dwarf if was visible only in the softest X-ray energy range. White dwarfs in EUV, selected also from the ROSAT all-sky survey by Marsh et al. (1997a,b), 129 white dwarf stars from Bergeron, Saffer & Liebert (1992), 200 white dwarfs from the Palomar Green survey (Green, Schmidt & Liebert (1986) analyzed by Liebert & Bergeron (1995) - it is only a few samples of these objects.

The Sloan Digital Sky Survey project (York et al. 2000) provide us large amount of very interesting data. Based on Data Release 1 and 4 (DR1 and DR4, respectively) there were made two catalogues by Kleinman et al. (2004) and Eisenstein et al. (2006), which contain 2551 and 9316 objects, respectively. Used identification methods did not allow to find all white dwarfs with whole range of effective temperatures and types in data sample. Kleinman et al. (2004) chose white dwarf candidates based on dereddened colour indexes  $u - g$  and  $g - r$  and a magnitude in  $u$  filter. Selected white dwarf candidates was next verified by visual inspection

and prescribed its type - DA, DB, DZ etc. After this procedure, spectra of selected objects were fitted by theoretical DA and DB spectra.

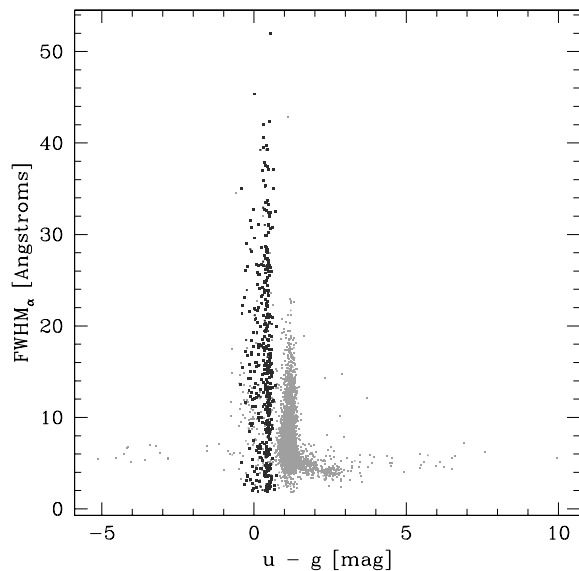
Eisenstein et al. (2006) disposed larger amount of data so they used more automatic selection procedure. They select stars fulfilled applicable criteria (see details in Eisenstein et al. 2006). In this manner they obtain sample of blue stars, which observational spectra were fitted by theoretical spectra. Stars with parameters characteristic for white dwarfs were next verified and classified during different tests including visual inspection. This method has some limitations, for example does not work for stars cooler than 8000K.

We intend to find a method of the white dwarf candidates selection - or, if it is possible, white dwarfs itself - based only on photometric and spectral features, chosen to obtain the best distinguishing between white dwarf stars and other type objects. Before we start fitting theoretical model atmospheres to observing spectra.

Not for the first time we have used data from the Sloan Digital Sky Survey (York et al. 2000). We chose Data Release 5 (DR5) and we selected spectral data for 10% randomly choosing objects. In this manner we obtained very imposing amount of nearly 16000 different type objects, including galaxies, quasars, stars, and of course white dwarfs. Additionally we also used white dwarfs identified in SDSS DR4 by Eisenstein et al. (2006), treating these stars on the one hand as a potential help to improve our white dwarfs selection method, on the other hand as a control data.

## 2. Balmer lines and their parameters

The most characteristic feature of many DA white dwarf spectra is a presence of wide, hydrogen absorption Balmer lines (except for the hottest objects). It would appear that it should be a good selection criteria of degenerated stars with high surface gravity, but not every white dwarf have wide Balmer lines. Nevertheless we decided to check this possibility. Because of large amount



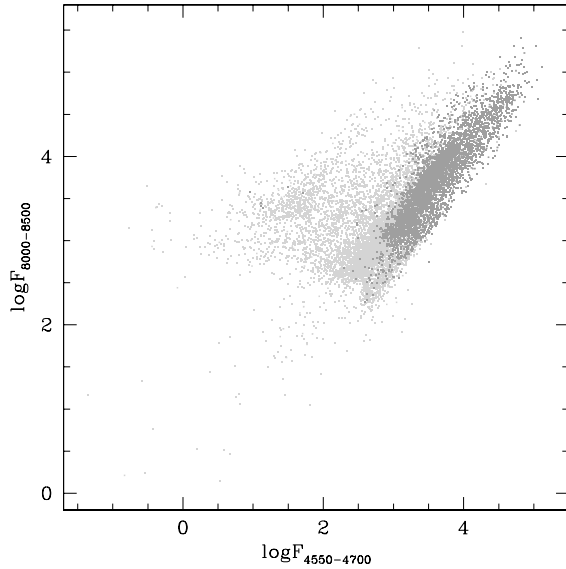
**Figure 1.** Colour index  $u - g$  versus FWHM of the  $H_\alpha$  Balmer line objects with  $H_\alpha$ ,  $H_\beta$ , and  $H_\gamma$  lines present in their spectra (dark gray dots). White dwarfs from SDSS DR4 belonging to our sample with detected Balmer lines was marked with black dots.

(15998) of objects in our sample we had to create proper software, which automatically finds hydrogen lines from Balmer series, and then calculates its various parameters like line widths at given depth, fluxes in lines etc. Fig. 1 shows one of the obtained results, a dependency of FWHM of Balmer  $H_\alpha$  line on colour index  $u - g$  for objects with  $H_\alpha$ ,  $H_\beta$ , and  $H_\gamma$  lines present in their spectra. Clearly seeing bimodal structure is not a by-product of our Balmer lines searching, but

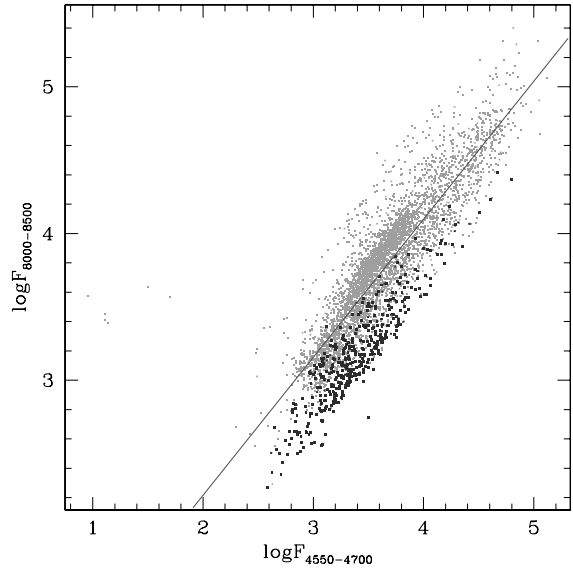
it is a result of a bimodal distribution of the colour index  $u - g$ . A location of the white dwarfs identified in SDSS DR4 (Kleinman et al. 2004), and belonged to our sample with detected Balmer lines, denoted by black dots, suggests, that all of the white dwarfs lies in the left part of this diagram, with colour indexes  $u - g < 0.7$ . In general, this is not a truth. Visual inspection shows, that some amount of white dwarf stars also lies in the right part of the diagram, and have larger values of colour indexes  $u - g$ . However, our requirement for the presence of hydrogen Balmer lines in spectra reduces our sample to practically star-like type objects only. In fact, it decreases a number of white dwarf candidates from 15998 to 4613. Unfortunately, reduced in this way sample does not contain the hottest white dwarf stars, because there is no Balmer lines visible in their spectra.

### 3. Fluxes in given ranges

Colour indexes based on *ugriz* photometry are not very useful for us, generally because the filters are too wide. So we decide to define own artificial filters, i.e. own wavelength ranges, in which we calculated fluxes. Choosing our filters we intended to not contain any Balmer lines.



**Figure 2.** Logarithms of fluxes relation, calculated in two wavelength ranges: 4550 – 4700Å and 8000 – 8500Å for all of 15998 objects in our sample (light gray dots). Objects with detected  $H_\alpha$ ,  $H_\beta$ , and  $H_\gamma$  lines was marked by dark gray dots.



**Figure 3.** The same as in Fig. 2, but for 4613 objects with Balmer lines only (dark gray dots). Black dots denote white dwarfs from SDSS DR4. Linear function  $y = 0.94118x + 0.33235$  is an approximate boundary between two regions visible in this diagram. Preliminary results of the visual inspection shows, that almost all of the 2202 objects located in the lower-right region looks like white dwarf stars.

In Fig. 2 we present a dependency of two flux logarithms, calculated in two arbitrarily chosen wavelength ranges: 4550 – 4700Å and 8000 – 8500Å for all of 15998 objects in our sample. Objects with detected  $H_\alpha$ ,  $H_\beta$ , and  $H_\gamma$  lines (dark gray dots) occupy well defined area, so we decided to watch them closer. Fig. 3 shows logarithms of fluxes in the same wavelength ranges as in Fig. 2, but for 4613 objects with Balmer lines only. It is not very difficult to see some

structure in this diagram. At least part of the objects divides to, not so bad, separate regions. This impression is additionally magnified by black dots showing positions of the white dwarfs from DR4, which occupy one of the mentioned above regions only. We decided to approximate a boundary between these two areas by the linear function  $y = 0.94118x + 0.33235$ , with empirically chosen constants. Preliminary results of the visual inspection shows, that spectra of almost all of the 2202 objects located in the lower-right region looks like white dwarf spectra. Because of relatively poor separation of these two areas, between 2411 objects belonging to the upper-left region we still could find relatively small amount of white dwarf stars, located close to the borderline.

#### 4. Conclusions

Our method of selecting white dwarf candidates is based on searching for objects with hydrogen Balmer lines visible in their spectra, and on flux calculations in well selected wavelength ranges. Preliminary results show that our method allows to select quite complete sample of white dwarf stars, under the above assumptions. Of course this method should be tested in detail, and it needs some improvements (for example increasing separation between two areas in Fig. 3, probably by choosing better wavelength ranges). It is quite possible, that using this method we shall be able to find also the hottest white dwarfs, which are too hot to show Balmer lines in their spectra, although we will need the other criteria to select star-like type objects. We plan to do this in future.

##### 4.1. Acknowledgments

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